National Institute of Environmental Health Sciences

Green systems biology - From single genomes, proteomes and metabolomes to ecosystems research and biotechnology

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Abstract:

Plants have shaped our human life form from the outset. With the emerging recognition of world population feeding, global climate change and limited energy resources with fossil fuels, the relevance of plant biology and biotechnology is becoming dramatically important. One key issue is to improve plant productivity and abiotic/biotic stress resistance in agriculture due to restricted land area and increasing environmental pressures. Another aspect is the development of CO(2)-neutral plant resources for fiber/biomass and biofuels: a transition from first generation plants like sugar cane, maize and other important nutritional crops to second and third generation energy crops such as Miscanthus and trees for lignocellulose and algae for biomass and feed, hydrogen and lipid production. At the same time we have to conserve and protect natural diversity and species richness as a foundation of our life on earth. Here, biodiversity banks are discussed as a foundation of current and future plant breeding research. Consequently, it can be anticipated that plant biology and ecology will have more indispensable future roles in all socio-economic aspects of our life than ever before. We therefore need an in-depth understanding of the physiology of single plant species for practical applications as well as the translation of this knowledge into complex natural as well as anthropogenic ecosystems. Latest developments in biological and bioanalytical research will lead into a paradigm shift towards trying to understand organisms at a systems level and in their ecosystemic context: (i) shotgun and next-generation genome sequencing, gene reconstruction and annotation, (ii) genome-scale molecular analysis using OMICS technologies and (iii) computer-assisted analysis, modeling and interpretation of biological data. Systems biology combines these molecular data, genetic evolution, environmental cues and species interaction with the understanding, modeling and prediction of active biochemical networks up to whole species populations. This process relies on the development of new technologies for the analysis of molecular data, especially genomics, metabolomics and proteomics data. The ambitious aim of these non-targeted 'omic' technologies is to extend our understanding beyond the analysis of separated parts of the system, in contrast to traditional reductionistic hypothesis-driven approaches. The consequent integration of genotyping, pheno/morphotyping and the analysis of the molecular phenotype using metabolomics, proteomics and transcriptomics will reveal a novel understanding of plant metabolism and its interaction with the environment. The analysis of single model systems - plants, fungi, animals and bacteria - will finally emerge in the analysis of populations of plants and other organisms and their adaptation to the ecological niche. In parallel, this novel understanding of ecophysiology will translate into knowledge-based approaches in crop plant biotechnology and marker- or genome-assisted breeding approaches. In this review the foundations of green systems biology are described and applications in ecosystems research are presented. Knowledge exchange of ecosystems research and green biotechnology merging into green systems biology is anticipated based on the principles of natural variation, biodiversity and the genotype-phenotype environment relationship as the fundamental drivers of

ecology and evolution.

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Resource Description

Exposure :

weather or climate related pathway by which climate change affects health

Unspecified Exposure

Geographic Feature:

resource focuses on specific type of geography

None or Unspecified

Geographic Location:

resource focuses on specific location

Global or Unspecified

Health Impact:

specification of health effect or disease related to climate change exposure

Health Outcome Unspecified

Medical Community Engagement:

resource focus on how the medical community discusses or acts to address health impacts of climate change

A focus of content

Mitigation/Adaptation:

mitigation or adaptation strategy is a focus of resource

Adaptation, Mitigation

Model/Methodology:

type of model used or methodology development is a focus of resource

Methodology

Resource Type:

format or standard characteristic of resource

Research Article, Review

Timescale:

time period studied

Time Scale Unspecified